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Assessment of Antarctic Tourism Waste Disposal and Management Strategies towards a Sustainable Ecosystem

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Abstract

Over the past two decades, Antarctica has experienced a severe eco-environmental degradation due to tourism impacts. The new, diverse and complex tourism activities and technological advancements demonstrate the current regulatory system is insufficient. This study aims to analyze the Antarctic tourism impact, investigate the assessment methods and propose a dynamic management system. This paper suggests two assessment indicators i.e. Antarctic ecological footprint (ATEF) and Antarctic tourism environmental carrying capacity (ATECC) along with nine management strategies. A flowchart demonstrates dynamic process of impact analyses, assessment and management. This system can be deployed to design a dynamic regulatory system toward sustainable Antarctic tourism.

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Keywords: Antarctic tourism; impact; management; eco-environment

1. Introduction

The widespread climate change has recently become an issue of global concern. Examples of the effect of this change during the last decade are extinction of species, rising sea levels and increasing air temperature. International treaties such as the UN Framework Convention on Climate Change (FCCC, 1992) requested anticipation, prevention or minimization of the cause of global warming and mitigation its adverse effects. Although the exact source, time and mitigation way were still uncertain, human

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impacts were obvious cause for this phenomenon alongside the other plausible reasons. In this case, recreation activities undoubtedly contributed to the human and environmental impact. This impact was more decisive in pristine landscapes and wilderness regions (Wanhill & Buhalis, 1999).

Meanwhile, as one of the most extreme and desolate regions of the earth, Antarctic remained relatively pristine over the years due to its harsh physical conditions. However, over the past two decades, this area received a severe eco-environment degradation and tourism risk. Increased tourism activities often impact negatively on the fragile Antarctic ecosystem. Historically, the late 1950s were the time when the modern era of Antarctic tourist started. During most years between 1958 and 1987, the average number of Antarctic tourists was below 1000. In the 1993-1994, the numbers of tourist unprecedentedly exceeded the scientists who travelled to this area (Bastmeijer & Roura, 2004). In 2007-2008, the total number of tourists who travelled to this region was near 35000 (Liggett, McIntosh, Thompson, Gilbert, & Storey, 2011) (Fig.1).

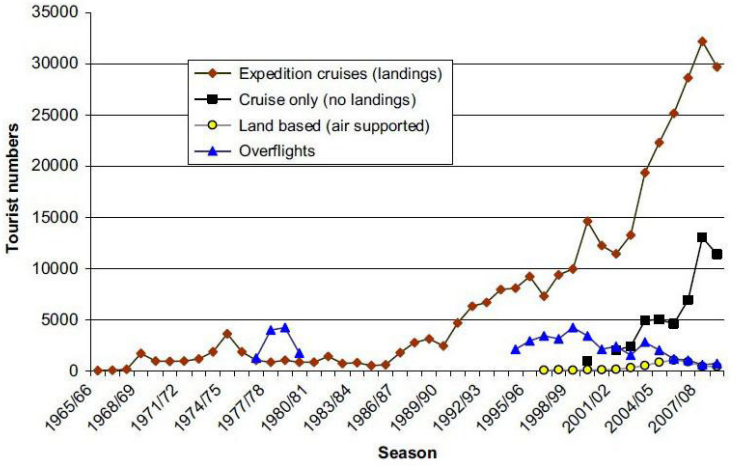

Fig. 1. Estimated numbers of Antarctic tourists in 1965-2009
(Source: Liggett et al., 2011)

2. Conceptual Background

Seven commercial tour operators founded the International Association of Antarctic Tour Operators (IAATO) in 1991 to work as a single dedicated organization (Liggett et al., 2011). Abiding by the tour operator guidelines, they agreed to adhere to the US Antarctic Conservation Act of 1978 and Environmental protocol of 1991 (Splettstoesser & Folks, 1994). Indeed, they aimed to advocate environmentally responsible travel to this area. According to the increasing number of tourists during the years, IAATO has accepted more members. As the principal legal authority, the Antarctic Treaty Consultative Parties (ATCPs) governed the area south of 60° S Latitude and managed the regulations (Liggett et al., 2011). The 1991 Protocol on Environmental Protection to the Antarctic Treaty (Madrid Protocol) formed one of the latest environmental standards of the Antarctic Treaty System (ATS). This treaty is associated with environment impact assessment, fauna and flora conservation, and controls over waste disposal and marine pollution. However, an increasing number of academics and parties regarded the Antarctic environment with concern (Bastmeijer & Roura, 2004; Haase, 2005; Kriwoken & Rootes, 2000). They highlighted the conflict between Antarctic tourism development and its ecological environmental protection. The increasing number of the visitors, other activities and destination and the potential of large vessels to crash particularly those which are not ice-strengthened attributed to this

concern. Thus, it seems necessary to anticipate further tourism growth and diversification which the current regulations are probably not efficient enough to control.

Previous studies mainly prospected Antarctic tourism according to three different views. The first was tourism contents, namely nature of tourism, activities and impacts (R. K. Headland, 1994; Lamers, Haase, & Amelung, 2008). The second was the assessment of the impacts through theoretical or empirical methods (Kriwoken & Rootes, 2000; Lamers, 2005). The third view was on management methods and strategies (Enzenbacher, 1992; Haase, 2005). However, there were a limited number of comprehensive and efficient studies adequately addressing diverse tourism activities, impact and management methods. Furthermore, researchers mostly noted the specific aspects such as air/water pollution or decrease in dominant prey and ignored non-polluted ecological effect. They focused on the microscopical impacts whereas the macroscopical effects had a critical role, as well. Various human and natural parameters associated simultaneously with the ecological system as a dynamic and complex system.

Assessment of the risk of anthropogenic climate change including tourism impact probably mitigated further irreversible large adverse effects toward a sustainable environment. From a general view, through the transition to sustainability, achievements should be assessed. Moreover, this assessment should be based on appropriate tools. These tools assisted policymakers to make the environment more sustainable (Devuyst & Hens, 2001). Thus, sustainability assessment is currently associated with environmental impact indicator/indices (Gössling, Hansson, Hörstmeier, & Saggel, 2002). Indeed, indicators were straightforward and mostly quantitative measures (Ness, Urbel-Piirsalu, Anderberg, & Olsson, 2007) with a wide scope and sensitive to change. They demonstrated the state of social, economic and/or environmental development, oftentimes at national scale (Harger & Meyer, 1996). Environmental impact assessment (EIA) evaluated environmental consequence of human activity (Green & Hunter, 1992) while Limits of acceptable change (LAC) evaluated acceptable changes of an environment (Simón, Narangajavana, & Marqués, 2004).

Local monitoring functioned and reflected regional circumstances to contextualize indicators, which meant that they did not take the impacts generated in the transit area into consideration. (Hughes, 2002; Li, 2004; Moore, Smith, & Newsome, 2003). Beside the regional aspects, the global consequences (impacts generated in the transit region) had a prominent role. Recent studies revealed that up to 90% of all transports are associated with the parameters contributed to global climate change (Becken, 2002; Høyer, 2000). Thus, regional indices were not sufficient enough to point out which form of travel or tourism destination contributed more to sustainable development (Gössling et al., 2002). Nevertheless, ecological footprint (EF), uniquely provided a global perspective (Castellani & Sala, 2012; Hunter & Shaw, 2007; Zhang, Xiang, & Li, 2012). EF can derive the recourse consumption and waste assimilation of a population (Rees, 1992). The concept was to compare the area supporting a publication with the corresponding land and/or sea area. Tourism ecological footprint (TEF) was the sum of biological productive land and water resources which produced the consumption and waste of a tourism population (Huiqin & Linchun, 2011). This indicator expressed the aggregate impact in terms of pressure on the global biosphere and travel-related impact components. Wackernagel, Lewan, and Hansson (1999) categorized this pressure into six components of space: arable land, pasture, forest, sea space, built-up land and fossil energy land.

Management of tourism ecological impact can be categorized into two key approaches (Azizi Jalilian, Danehkar, & Shaban Ali Fami, 2012). The first approach was direct strategy that tended to directly control over the tourists' behaviours. The second approach indirect strategy iwhich was more voluntary and attempted to affect tourists' decisions based on their behaviours. The former normally included prohibiting regulation and enforced tourists through fine or sanctions while the latter can be performed through incentive, education program, offered guidelines, facility upgrade and maintenance enhancement. (M. Needham & Rollins, 2009; M. D. Needham & Szuster, 2011).

Literature studies were found to be using two different methods of analysing. The first group investigated the tourism impact through theoretical and conceptual approaches. In contrast, empirical methods such as survey are applied by other studies. According to the current gap in relevant knowledge of tourism impact in Antarctica, this study applied the first method. A large number of literature studies were reviewed to enrich the context. In a well-understood context, empirical studies can be further conducted to examine the results of proposed model. Thus, this paper aims to analyze the Antarctic tourism impact, investigate the assessment methods and propose a dynamic management system. In total, Antarctic tourism impact includes: environment population, non population effects and interregional diffusion. This paper investigates the negative impacts involving the tourism industry, i.e. tourism developers, tourists and the enterprises. Providing a view on available impact assessment tools is another objective of the present work. This assessment requires appropriate tools and indices. Practical management strategies were finally proposed in detail. These management strategies are involved in a wide range of environmental and human parameters.

3. Discussion

3.1. Influence of tourism developments

Tourism development includes a wide range of activities involved in construction and maintenance of facilities such as hotels, resorts, restaurants and scenic area, provided in any tourism destination**.** The construction and maintenance activities generate waste material and energy affecting the surrounding ecosystem. This effect is considerably higher in a pristine environment rather than urban areas. However, construction in Antarctic for tourism development was not at a high level (Lu et al., 2011) since Antarctic expeditions were mostly ship-based and visitors only visit ashore for a short duration. Tourism related constructions in Antarctica were mostly for the air base stations and the support facilities. In addition to the facilities providing for the national Antarctic programmes, the affiliated stations provided the opportunity for the tour operators to use these airstrips as transport channels (Reich, 1980).

An NGO established the E-base in King George Island as the only non-governmental permanent tourism air-based facility. It concentrated on increasing the public awareness to protect the Antarctic environment (Bastmeijer, Lamers, & Harcha, 2008). Moreover, a Canadian company founded a semi permanent camp at Patriot Hills in 1987. This camp provided logistic support and organized flights for airborne tourism operations and private expeditions (Headland, 1989). Airborne tourism development did not receive high demand by Antarctic tourists due to the high prices of expeditions. In addition, regulatory mechanism applied by the ATCPs mostly addressed ship-based tourism. However, policymakers revealed concerns about construction and demolition of infrastructures in Antarctica (Liggett et al., 2011).

3.2. Tourists impact

Based on IAATO (2011) reports, current tourism activities in Antarctica can be divided into eight key groups: ship borne expeditions, small boat landing, kayaking, extended walk, station visit, scuba diving, science support and camping (Fig. 2). Tourists were interested to visit the most picturesque and wildlife-rich areas with vulnerable ecosystem. Table 1 represents Antarctic tourism environment pressure including polluting, non-polluting and interregional impacts. Major negative impacts of tourists' activities are: site degradation, disposal generation, wildlife disturbance, fauna and flora diseases, damage to the ice layers and fresh water consumption. Meanwhile, visitors who travelled individually or in small parties

created a new generation of Antarctic tourists. The potential environmental degradation by this group is high since they do not have adequate information about the environment they encounter.

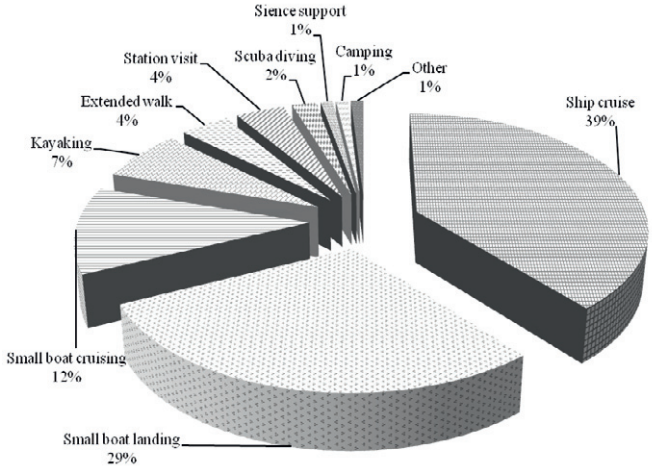

Fig. 2. Distribution of Antarctic tourism activities in 2010-2011
(Source: IAATO, 2011)

Table 1. Polluted, non-polluted and interregional impact of the three parties in Antarctic tourism

Developers	Construction and demolition waste
	Wildlife disturbance
	Damage to ice layers
	Generate disposal
	Air pollution
	Aesthetic issues
Tourists	Degradation of visited environment and heritage sites
	Generation of rubbish and littering,
	Wildlife disturbance
	Ice-land damages
	Sewage disposal
	Fauna and flora diseases
	Fresh water consumption
Enterprises*	Engine fallout
	Potential of crash
	Generation of compatible material and conflict with recycling system
	Ice breaking
	Oil spoils
	Wildlife threat by noise pollution

* Impacts of this section cover the transition area as well (global impact)

3.3. Role of enterprises

This group included all the facilities and stakeholders involved in providing services for tourists. In terms of facilities, large vessels were the highest potential risk. They might have a crash, an accident, grounded on uncharted rocks, break the ice lands or pollute the water. Indeed, the cruise traffic around the frequently visited sites, increased environment stresses. Operators preferred to apply large vessels since small vessel were not economic enough. Nevertheless, in 2009, the International Convention for the Prevention of Pollution from Ship prohibited the use and carriage of heavy and intermediate fuel oils for ships in the Antarctic treaty area. This affected cruise-by tours by large ships. Consequently, the number of Antarctic tourism in 2011-2012 declined to approximately half of 2006-2007 figures (IAATO, 2011). Liggett et al. (2011) elaborated 29 accidents and incidents such as damage, aircraft crash, ship grounding and oil spoil recorded between 1967 and 2003. Amazingly, nearly half of them were accrued during the last 12 years. Although IAATO has provided a swift accessible precautions and assistance, the sinking of MS Explorer in 2007 revealed the potential risk for vessels crash still remains. Alongside ship-based travelling, airborne travelling can provide potential of crash, noise and air pollution and wildlife disturbance. Antarctic air-based tourism has not grown over the recent years despite its increase between 1950s and 1970s. Interestingly, the number of tourists to this area via flight seemed to have steadily declined during the past few years (Fig. 1). However, the potential of crash and degradation related to air based supports contributed to the concern on Antarctic ecosystem.

3.4. Impact assessment

Researchers normally apply TEF for different time, origin, destination, and travelling based on primary and secondary data (Becken, 2002; Gössling et al., 2002). From a different view, Gössling et al. (2002) divided the total TEF value into two components: transit-related and destination-related. They included emissions of flight to the category of fossil energy as a potential for climate warming and analyzed TEF related to leisure tourism based on Seychelles. They also asserted a concern that a single long-distance travel required a large equivalent area. The authors suggested that airborne tourism should be discouraged. Hunter and Shaw (2007) proposed a 5-step procedure to calculate the annual TEF for international tourism on air travel. It included estimating flight distance, energy use per tourists, equivalent land area, aircraft irradiative emissions and multiplying by an equivalent factor. They suggested extending the concept of TEF incorporating different methods and transportation approaches to individual source domains based on national TEF data. Data are collected on the resources consumption by tourism products in a given region. According to the confirmed regional and global tourism impact, ATEF can assess total environmental pressure of tourism in Antarctica. ATEF used localized monitoring data and individually estimated the different distances, time and travel approaches.

Fragile environments can be easily disrupted under insurgence of visitors. Overcapacity can make substantial, irreversible consequences on an environment. The tourism environmental carrying capacity (TECC) was developed on a concept of the assessing the ability of an environment to accommodate people and covered three main aspects: social, economic and environmental status (O'Reilly, 1986). TECC represented the maximum population who can consume resources of a region without intolerable degradation while keeping the recreational experience at an acceptable level (Mathieson & Wall, 1987). Indeed, TECC described the relationship between tourists and the natural environment they visit (Abernethy, 2001). Hence, to estimate the tolerance of Antarctic environment to contain tourists and related facilities, a reliable and well-suited tool, namely ATECC should be applied. In this case, a well-planned environmental monitoring need to be conducted (Buckley, 1999). O'Reilly (1986) discussed the parameters that influenced TECC in two groups: tourists' characteristics e.g. socioeconomics and forms

of behaviour, and destination area characteristics such as natural features, political status and level of tourism development. Thus, TECC depended on behavioural experiences and biophysical aspects (Saveriades, 2000) and varied in terms of location, tourists' pattern of activity, speed of tourism development and level of technical advancement (Simón et al., 2004). Thus, it should be individually estimated for each case.

For Antarctica region, ATECC can be derived based on a reliable and well-planned data monitoring in terms of the number of tourists, their socioeconomic situations and pattern of activity, current tourism development, available facilities and biological system status. It should be considered that ATEF and ATECC are dynamic measures and responsive to the time and environmental conditions and should be kept updated. Tourism sustainability status can be measured with tourism footprint and environmental carrying capacity correlation (Huiqin & Linchun, 2011). Consequently, once the amount of ATEF exceeds ATECC, the tourism status in Antarctica will not be sustainable, the current regulatory system should be improved, and the received impacts need to be managed through appropriate strategies (Fig. 3).

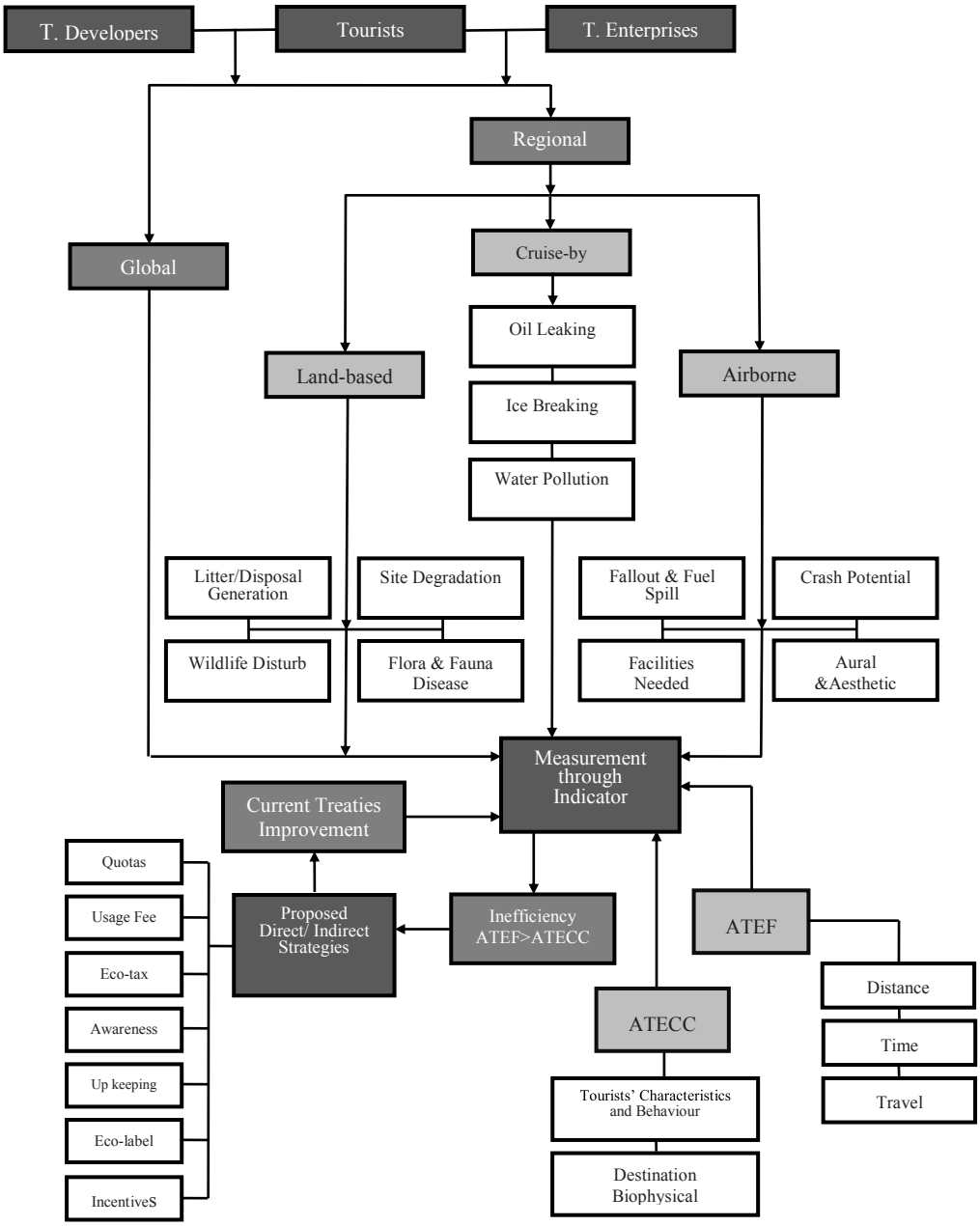

Fig. 3. Proposed Antarctic tourism impact, assessment, and management procedure

4. Recommended Management Strategies

To manage the tourism environmental pressure, efficient policy instruments are needed including economic regulations and institutional instruments (Logar, 2010).

The design and implementation of management mechanisms are complicated due to the diverse and complex patterns of tourists' activities. New tourism activities can have different environment pressures and impacts. Thus, future tourism might lead to extended challenge in the current Antarctic regulation system. Technical advancement, the new travelling approaches and additional destinations contributed to inefficiency of the current instruments. The new trends need new sets of anticipation, distinct regulations and management strategies. With respect to the previous descriptions and the characteristics of Antarctic ecosystem and its current tourism status, this study proposes the following management strategies categorized into direct and indirect groups. Obviously, the strategies should be updated frequently with respect to impact assessments results (Fig. 3).

4.1. Direct strategies

Restrict use (quotas) (Brown, Turner, Hameed, & Bateman, 1997; M. D. Needham & Szuster, 2010): Many researchers have proposed a set limit on the number of visitors to the Antarctic (Gössling, 1999). It can control over environment overcrowding, enhance visitors experience, raise the quality of destination environment and provide a competition for enterprises to improve their services. The efficiency and benefit of the strategy varied largely with the uniqueness, attractiveness and sensitivity of the visiting place and associated with the carrying capacity of the environment. It can be prioritized by related parties. Such policy controls overcrowding and alleviates environment resources degradation. The number of acceptable tourists to a particular site can be estimated through the presented ATECC methods. However, limiting the number of visitors, might lead to increased illegal travel to Antarctica. Thus, it should be only implemented to avoid overcrowding.

Zoning: to limit the activity conducted by tourists at individual areas. Zoning is the level of sensitivity of an area including its ecosystem status, tourism history of presence and pattern of activity, and socio economic characteristics of the target population. The updated data have to be collected to classify different environmental status and sensitivity. This strategy can protect sensitive areas from overcrowding and provide a balanced distribution of visitors.

Service fee: to manage a particular payment system on the tour operators conducted by related parties. Service fee can vary in terms of seasonal tourism dimensions and the operators' economic benefit. The rate of this payment varies with the sensitivity of the target environments. The more the environment is sensitive, the higher fee the operators have to pay.

Dynamic eco-taxes: to levy a tax on tourists, earmarked for environmental purposes. It is estimated on the attributions of the destination that the tourists visit i.e., sensitivity and attractiveness and the time of usage. It can improve the quality and enhance the image of the destination (Logar, 2010).

Site upkeep: related stakeholders should provide an in-situ protection plan. It can be conducted by staff to monitor the visitors at different sites. They can control over the tourists' behaviours during the visit. Rubbish generation, littering, sewage disposal and wildlife disturbance level should decrease under this plan.

4.2. Indirect strategies

Enhance visitors' awareness: to enhance the tourists' awareness on the environmental effect of their activities and the consequences of this effect on global warming and diseases. All the related stakeholders can participate in this program.

Eco-label: to administer a labelling system on the services and facilities provided for the tourists for compatibility with the ecosystem under supervision of an impartial organization. It even covers vessels, construction materials and the products which tourism activities use. It can increase competitions between the operators and enhance their services. It also encourages the illegal operators to register and receive the label.

Financial incentives: to encourage tourists and stakeholders to contribute to environmental protection through financial incentives. Subsidizing some services, such as registration, encourages illegal operators to register and follow the regulatory system (Logar, 2010). It includes increasing payment for threatening activities and reducing the payment for neutral activities. Furthermore, the responsible parties can introduce and provide cheaper, environmental friendly equipment for the tourists (Logar, 2010).

The outcome of strategies implementations vary according to different sites (M. D. Needham & Szuster, 2010) and the characteristics of the tourists. The management process has to be dynamic to cope with different impacts. Normally, direct instruments are less favoured by tourists (Manning, 2007). To evaluate the efficiency of the instruments, their level of acceptance and feasibility of implementation should be analyzed (Logar, 2010).

5. Conclusion

Although the available literature is very limited, this paper addresses an extensive context on Antarctic tourism attributes. As a complex and dynamic system influenced by various environmental and human parameters, the assessment of the ecological status is a complicated process. Appropriate methods and indices of assessment might help to complete this process. In fact, a three-step process i.e. impact analysis, assessment and applying management strategies is necessary to cope with the environmental impact of tourism in Antarctica. A well-planned analysis procedure highlights the potential risk of the parts of the ecosystem in relation with diverse and complex tourism activities. It should cover the three parties involved in Antarctic tourism, namely tourism developers, tourists and enterprises. A reliable in-situ data collection needs to be conducted to achieve this aim. A comprehensive travel procedure including transition area should be considered for a comprehensive analysis covering regional and interregional impacts.

ATEF assessed the regional and global aspects of tourism in Antarctica. It varied individually for different distances, time and travel approaches. ATECC evaluated the ability of an Antarctic environment to accommodate a population. This indicator represented the level of visitors' usage that a region can support. The measure varied in terms of behavioural experiences and biophysical aspects. Environmental sustainability status is not a static value. It depended on tourism development, patterns of tourists' activities and technical enhancements. Hence, a dynamic assessment and management system should monitor the conditions of the environment and the population it contained. This paper proposes eight direct and indirect management strategies namely: quotas, zoning, service fee, eco-tax, site upkeep, awareness enhancement, eco-label and financial incentives. The procedure may be useful for policymakers to provide a reliable view of Antarctic environment sustainability in terms of tourism pressure. Further studies can empirically investigate the performance of this model and propose complementary strategies.

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